Chapter 7 Practice Test Questions for Multiple Choice

- This is practice - Do NOT cheat yourself of finding out what you are capable of doing. Be sure you follow the testing conditions outlined below.
- DO NOT USE A CALCULATOR. You may use ONLY the green periodic table.
- Try to work at a pace of 1.2 min per question. Time yourself. It is important that you practice working for speed.
- Then when time is up, continue working and finish as necessary.

1. Which of the following contains only atoms that are diamagnetic in their ground state?
   a. Kr, Ca, and P
   b. Cl, Mg, and Cd
   c. Ar, K, and Ba
   d. He, Sr, and C
   e. Ne, Be, and Zn

2. A valence electron from an arsenic atom might have an electron with the following set of quantum numbers in the ground state.
   a. n= 4; l = 1; m_l= 0; m_s= +½
   b. n= 4; l = 1; m_l= 2; m_s= −½
   c. n= 3; l = 1; m_l= 0; m_s= +½
   d. n= 5; l = 1; m_l= −1; m_s= −½
   e. n= 4; l = 2; m_l= +1; m_s= +½

3. Calcium reacts with element X to form an ionic compound. If the state electron configuration of X is $1s^22s^22p^4$, what us the simplest formula for this compound?
   a. CaX
   b. CaX_2
   c. Ca_4X_2
   d. Ca_2X_2
   e. Ca_2X_3

4. The ground-state configuration of Fe^{2+} is which of the following?
   a. $1s^22s^22p^63s^23p^63d^54s^1$
   b. $1s^22s^22p^63s^23p^63d^6$
   c. $1s^22s^22p^63s^23p^64s^23d^6$
   d. $1s^22s^22p^63s^23p^63d^84s^2$
   e. $1s^22s^22p^63s^23p^63d^44s^2$

5. In the ground state the highest- energy electron of a rubidium atom might have which of the following sets of quantum numbers?
   a. n=5; l =0; m_l=1; m_s=+½
   b. n=5; l =1; m_l=1; m_s=+½
   c. n=4; l =0; m_l=0; m_s=+½
   d. n=5; l=0; m_l=0; m_s=+½
   e. n=6; l =0; m_l=0; m_s=+½

The next four questions refer to the following orbital diagrams.

(A) 1s___ 2s___

(B) 1s___ 2s___ 2p___ ___ ___ 3s___

(C) [Kr]5s___ 4d___ ___ ___ ___ ___

(D) [Ne] 3s___ 3p ___ ___ ___

(E) 1s___ 2s___ 2p___ ___ ___

6. The least reactive element is represented by:
7. The transition metal is represented by:
8. The most chemically reactive element is represented by:
9. The element in an excited state is represented by:

Use the following ground-state electron configurations for the following four questions.

(A) $1s^21p^62s^22p^3$

(B) $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^1$

(C) $1s^22s^22p^63s^23p^63d^{10}$

(D) $1s^22s^22p^5$

(E) $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$

10. The electron configuration of a halogen is:
11. This is a possible configuration for a transition metal atom.
12. This electron configuration is not possible.
13. This is a possible configuration of a transition metal ion.

The following answers are to be used for the following four questions:

(A) Pauli exclusion principle

(B) electron shielding

(C) the wave properties matter

(D) Heisenberg uncertainty principle

(E) Hund's rule

14. The exact position of an electron is not known.

15. Oxygen atoms, in their ground state, are paramagnetic.

16. An atomic orbital can hold no more than two electrons.

17. The reason the 4s orbital fills before the 3d:

18. Which of the following quantum numbers is unacceptable?

    n, *l*, $m_{l,}$ m_s

    a. 4, 3, -2, +½
    b. 3, 0, +1, -½
    c. 3, 0, 0, -½
    d. 3, 1, 1, +½
    e. 2, 0, 0, -½

19. The differentiating electron in gallium, Ga, is the single $4p^1$ electron. A valid set of quantum numbers for this electron is

    n *l* m_l m_2

    a. 3, 2, 1, +½
    b. 3, 1, −1, +½
    c. 4, 0, 0, +½
    d. 4, −1, +1, +½
    e. 4, 1, −1, +½

20. If the angular momentum (second) quantum number L equals 3, the total number of allowed orbitals in just that sub-level is

    a. 1
    b. 3
    c. 5
    d. 7
    e. 9

21. The element with the ground state electron configuration (spectroscopic notation) of [Ar] $3d^74s^2$ is

    a. Mg
    b. K
    c. Ar
    d. Co
    e. Ni

22. The electron configuration for the element antimony, $_{51}$Sb, is

    a. [Na] $3s^22d^{10}3p^3$
    b. [Ar] $4s^23d^{10}4p^5$
    c. [Ar] $4s^23d^{10}4p^3$
    d. [Kr] $5s^24d^{10}5p^3$
    e. [Kr] $5s^24d^{10}5p^5$

23. Atomic radii decrease from left to right across a period because of

    a. an increase in effective nuclear charge
    b. an increase in energy level (n)
    c. an increase in orbital size (*l*)
    d. an increase in shielding
    e. more electrons

24. The number of unpaired electrons in the chromium atom is

    a. 1
    b. 2
    c. 4
    d. 5
    e. 6

25. The correct ordering of atoms in progressively decreasing ionization energy is

    a. F > O > C > Li > Na
    b. Na > Li > C > O > F
    c. F > O > C > Na > Li
    d. C > O > F > Li > Na
    e. O > F > C > Na > Li

26. Electron affinity is the

    a. energy required to remove an electron from an atom in the gaseous state.
    b. energy released when an electron is gained by an atom in it's standard state.
    c. maximum energy required to remove an electron from an atom in it's standard state.
    d. energy involved when an electron is gained by an atom in the gaseous state.
    e. energy gained by an electron when it is absorbed by another electron.

27. What is the most likely electron configuration for a sodium ion in its ground state?

    a. $1s^22s^22p^5$
    b. $1s^22s^22p^6$
    c. $1s^22s^22p^63s^1$
    d. $1s^22s^22p^53s^2$
    e. $1s^22s^22p^63s^2$

28. Which of the following statements is true regarding sodium and chlorine?
    a. Sodium has greater electronegativity and a larger first ionization energy.
    b. Sodium has a larger first ionization energy and a larger atomic radius.
    c. Chlorine has a larger atomic radius and a greater electronegativity.
    d. Chlorine has a greater electronegtivity and a larger first ionization energy.
    e. Chlorine has a larger atomic radius and a larger first ionization energy.

29. Which of the following represents the energy of the single electron in a hydrogen atom when it is in the n=4 state?
    a. $\left(\frac{-2.178x10^{-18}}{2}\right) joules$
    b. $\left(\frac{-2.178x10^{-18}}{4}\right) joules$
    c. $\left(\frac{-2.178x10^{-18}}{8}\right) joules$
    d. $\left(\frac{-2.178x10^{-18}}{16}\right) joules$
    e. $\left(\frac{-2.178x10^{-18}}{64}\right) joules$

The following choices refer to the following four questions.

(A) C

(B) N

(C) O

(D) F

(E) Ne

30. This is the most electronegative element.

31. The nuclear decay of an isotope of this element is used to measure the age of archaeological artifacts.

32. All of the electrons in this element are spin- paired.

33. This element, present as a diatomic gas, makes up most of the earth's atmosphere.

The following choices refer to the following 3 questions.

(A) Hg

(B) Si

(C) Cu

(D) Zn

(E) Ag

34. This element is commonly used in the manufacturing of semiconductors.

35. This element is liquid at room temperature.

36. After oxygen, this is by far the most common element in the earth's crust.

37. Which of the following could be the quantum numbers (n, *l*, m_L, m_s) for the valence electron in a potassium atom in its ground state?
    a. 3, 0, 0, ½
    b. 3, 1, 1, −½
    c. 4, 0, 0, −½
    d. 4, 1, 1, ½
    e. 4, 2, 1, ½

38. Which of the following elements is diamagnetic?
    a. H
    b. Li
    c. Be
    d. B
    e. C

39. Which of the following rules states that no two electrons in an atom can have the same set of quantum numbers?
    a. Hund's rule
    b. The Heisenberg uncertainty principle
    c. The Pauli exclusion principle
    d. The de Broglie hypothesis
    e. The Bohr model

40. Which of the following is true of the alkali metal elements?
    a. They usually take the +2 oxidation state.
    b. They have oxides that act as acid anhydrides.
    c. They form covalent bonds with oxygen.
    d. They are generally found in nature in compounds.
    e. They have relatively large first ionization energies

41. Which of the following could be the quantum numbers (n, *l*, m_l, m_s) for the valence electron with the greatest energy in a phosphorous atom in ground state?
   a. 2, 0, 0, ½
   b. 2, 0, 1, −½
   c. 2, 1, 0, ½
   d. 3, 1, 1, ½
   e. 3, 2, 1, −½

42. Which of the following ions has the smallest ionic radius?
   a. O^{2-}
   b. F^-
   c. Na^+
   d. Mg^{2+}
   e. Al^{3+}

43. When an electron in a hydrogen atom makes the transition from the n=4 state to the n=2 state, blue light with a wavelength of 434 nm is emitted. Which of the following expressions gives the energy released by the transition?
   a. $\frac{(6.63x10^{-34})(3.00x10^{8})}{(4.34x10^{-7})}\ joules$
   b. $\frac{(6.63x10^{-34})(4.34x10^{-7})}{(3.00x10^{8})}\ joules$
   c. $\frac{(6.63x10^{-34})}{(3.00x10^{8})(4.34x10^{-7})}\ joules$
   d. $\frac{(4.34x10^{-7})}{(3.00x10^{8})(6.63x10^{-34})}\ joules$
   e. $(6.63x10^{-34})(4.34x10^{-7})\ joules$

44. A researcher listed the first five ionization energies (in kilojoules) for a silicon atom in order from first to fifth. Which of the following lists corresponds to the ionization energies for silicon?
   a. 780, 13,675, 14,110, 15,650, 16,100
   b. 780, 1,575, 14,110, 15,650, 16,100
   c. 780, 1,575, 3,220, 15,650, 16,100
   d. 780, 1,575, 3,220, 4,350, 16,100
   e. 780, 1,575, 3,220, 4,350, 5,340

45. The photoelectric effect shows that a minimum energy is needed to eject an electron from a piece of metal. This supports the idea of quantized energy because:
   a. increasing the brightness of the light makes the electrons move faster.
   b. changing the color, or wavelength, of the light keeps the electrons quantized at the same level.
   c. quantized energy is the only way that energy can be explained at the time of its discovery.
   d. it is shown that a minimum frequency of light is needed. Making the light brighter doesn't help.
   e. all changes in brightness (intensity) and color (frequency) have no effect on the ejection of electrons from a metal.

46. What is the energy (in Joules) if a photon that has a frequency of 4.00×10^{10} Hz? The Plank Constant has a value of 6.626×10^{-34} J/s.
   a. 1.99×10^{-25}
   b. 2.65×10^{-23}
   c. 7.50×10^{-3}
   d. 1.20×10^{19}
   e. 6.02×10^{23}

47. The location of an electron is identified by the atomic orbital it is in. Which properties of an atomic orbital are specified by the first three quantum numbers?
   a. Length, width, and height
   b. Mass, speed, and direction
   c. Size, shape, and orientation
   d. Size, exact location, and velocity
   e. Color, frequency, and wavelength

48. Which of the following is the ground state electron configuration of an oxide ion?
   a. $1s^22s^22p^4$
   b. $1s^22s^22p^5$
   c. $1s^22s^22p^6$
   d. $1s^22s^22p^63s^1$
   e. $1s^22s^22p^63s^2$

49. Phosphorus (−72) has a less negative electron affinity than silicon (−134). This is explained by the fact that an electron added to phosphorus is added to:
   a. a filled orbital.
   b. a new subshell.
   c. an empty orbital.
   d. a half- filled orbital.
   e. a new valence shell.

50. Which atom has the largest covalent radius?
   a. Argon
   b. Arsenic
   c. Phosphorus
   d. Selenium
   e. Sulfur

ANSWERS

1. e Substances are diamagnetic, no response to a magnetic field, if they have all paired electrons. This means that they must be elements in columns headed by Be-s^2, Zn-s^2d^{10}, and He-S^2(and s^2p^6)
2. a valence electrons for arsenic are $4s^24p^3$. Thus we are looking for n=4, and L=0(s) or 1(p), then m_L will be in response to whatever L value. b is not valid as m_L = 2 is not possible for L=1
3. a The electron configuration given, tells you it is oxygen and would have a charge of 2−, thus Ca^{2+} and O^{2-} = CaO or CaX.
4. a Fe^{2+} has lost 2 electrons, it would be the $4s^2$ valence electrons that would be ripped off because, while they are not the last electrons in (highest energy) they are the most exposed in the outermost energy level. The paired electron in the d set of orbitals would move to the 4s orbital. The energy expended in moving the e- further from the nucleus would be recovered in less repulsion and stability achieved by a half-full d set of orbitals.
5. d The last, highest energy electron in Rb is $5s^1$. The s orbital is signified by L=1.
6. e Least reactive = looking for a Noble gas.
7. c Looking for an element with unfinished d orbitals (or d^{10}).
8. b Most reactive = looking for an alkali metal. Both a and b meet that requirement, and since b is lower in the column, with electrons further form the nucleus, it is more reactive because the electrons can be stolen more easily.
9. a Excited state = looking for a configuration in which a lower orbital is unfilled while electrons are in higher energy orbitals.
10. d Halogens are always ns^2 np^5
11. b "c" does not meet the criteria because it is missing its $4s^2$ electrons, thus it is a transition metal ion, Zn^{2+}
12. a the 1p orbital in "a" is impossible.
13. c As described in #11, c would be the answer.
14. d The dual nature of matter (both particle and wave properties of matter places limitations on how precisely we can know both the location and momentum of any objects. For objects that surround us on a daily basis, this is unimportant, but for subatomic particles such as the electron, this principle is important. This is what has lead to the fact that we can so precisely describe and electron's energy, but we describe its location inside an atom in terms of probabilities.
15. e Paramagnetism refers to a substances response to a magnetic field which is due to its unpaired electrons with spin all in the same direction. Hund's rule says that for electrons in degenerate orbitals (all the same subset) the lowest energy is attained if the number of electrons with the same spin is maximized. This can be accomplished when degenerate electrons spread out with in its subset of orbitals. It is not likely that you will need to know the term "Hund's Rule" on the AP exam, but you will need to apply the concept.
16. a The Pauli exclusion principle states that no two electrons in an atom can have the same set of orbital numbers: n, L, m_L, m_s. Thus if we want to put more than one electron in any orbital and satisfy the Pauli exclusion principle, the only option would be to assign two different m_s quantum numbers, and since there are only 2 choices for m_s: +½ and −½, the conclusion is that any orbital can hold a maximum of two electrons with opposite spin.
17. b The 3d orbitals are shielded more efficiently than the 4s orbitals because the 4s orbitals "penetrates" deeper into the core, making the 4s a lower energy orbital as electrons in that orbital will "feel" the nuclear charge better. This allows the 4s orbital to fill before the 3d orbital.
18. b If the second quantum number, L, is 0, then the third quantum number, m_L, can only be 0.
19. e For $4p^1$, n must = 4, and p is signified by L = 1, thus "e" is the only valid choice.
20. d L = 0 means s, L = 1 means p, L = 2 means d and L = 3 means f, thus 7 allowed orbitals
21. d Ap is likely to write the d and s orbitals in reverse order as shown in this problem. I would prefer that they write [Ar] $4s^23d^7$, but they may not. Don't let it fool you.
22. d Hopefully you need no explanation for this problem.
23. a Because the electrons are not shielded by any new layers of inner "core" electrons, the added nuclear charge in atoms further to the right in the periodic table cause a greater effective positive electrostatic force on valence electrons. This draws those valence electrons closer and reduces the size of the atomic radii.
24. e You might be inclined to think that the chromium atom should be $4s^23d^4$, however, the energy expended by moving one of the 4s electrons into the higher energy 3d set of orbitals, is more than compensated by the stability achieved by the half full set of d orbitals, thus the over all configuration is more stable as $4s^13d^5$, resulting in 6 unpaired electrons.
25. a Ionization energy is inversely proportional to size. Because size increases left across chart and down the chart, "a" is the only choice. Can you discuss why N is not in this sequence?
26. d Electron affinity is not the opposite of ionization energy. "d" says the energy "involved" because while energy is usually released when an electron is added (negative values), for some atoms, energy is required (positive value) to force the electron in.

27. b Be sure and note that the question asks about a sodium ion, which of course would have lost its s^1 electron.

28. d chlorine is smaller in size, due to its increased effective nuclear charge which also causes its larger first ionization eenrgy.

29. d It is highly unlikely that you would have to use this formula in the MC portion of the AP exam - check your formula sheet to find the formula, in case you needed to use it in the FR section.

30. d Electronegativity increases moving up and to the right on the periodic table.

31. a Carbon-14 can be used to date organic materials (anything containing carbon) up to 5,000 years old, after which the amount of ^{14}C remaining would be unable to be measured.

32. e "Spin-paired" means, two electrons in the same orbital. This will occurred in Be, Zn and He columns of the periodic table.

33. b N_2 is of course ~80% of the earth's atmosphere.

34. b Si is a metalloid, a semi-conductor, having metallic and nonmetallic properties, most notably, the ability to conduct electricity - or not under different conditions

35. a mercury (Bromine is the other element that is liquid at standard conditions.)

36. b Sand is SiO_2, thus Si is the next most common element in the earth's crust.

37. c Potassium only has a single 4s1 valence electron, thus n=4, L=0

38. c Substances that are diamagnetic show no response to a magnetic field and will have all paired electrons. Be-s^2, meets that paired electron criteria.

39. c As discussed in #16, it is not likely that you need to know the name, just the principle for the AP exam.

40. d Since alkali metals are so reactive, they will always be found in nature as compounds, never as a pure metallic element.

41. d Phosphorus' highest energy electron would be 3p. Thus n=3, and L=1

42. e Positive ions are always smaller than their parent atoms. Al3+ would be the smallest of the three listed because it has the greatest proton/neutron ratio, causing the electron cloud to "skootch" in.

43. a Although it is unlikely, that you will need to know the atomic structure equations on the formula sheet, it might be worth putting these two in $E = h\nu$ and $c = \lambda\nu$. In this problem the n values give for the electron are not necessary to solve the problem. You are solving for E in the first equation listed, but you have been given a wavelength not a frequency, so solve $c = \lambda\nu$ for ν and substitute into $E = h\nu$, resulting in $E = hc/\lambda$. Since c as 3 x 108 is in m/s, the wavelength given, 434 nm has been converted to meters, 434 nm * $1m/^{1}0^{9}nm = 4.34 \times ^{10-7}$ m. While I am quite sure you will never have to have h, Planck's constant memorized, it is easy enough to figure it is the remaining number in the problem. Further, it is probably the smallest number you will ever have deal with!

44. d Silicon has four valence electrons, thus a very high increase would be expected for the fifth ionization energy.

45. d It is the photoelectric effect for which in 1921 Einstein won his one and only Noble prize. While it is not so likely to be on the AP exam, one can never be sure. The photons of a light beam have a characteristic energy determined by the frequency of the light. In the photoemission process, if an electron within some material absorbs the energy of one photon that is of high enough energy the electron will ejected. If the photon energy is too low, the electron is unable to escape the material. Increasing the intensity of the light beam increases the number of photons in the light beam, but does not increase the energy that each electron possesses. The energy of the emitted electrons does not depend on the intensity (more photons) of the incoming light, but only on the energy or frequency of each individual photon. Electrons can absorb energy from photons when irradiated, but they usually follow an "all or nothing" principle. All of the energy from one photon must be absorbed and used to liberate one electron from atomic binding, or else the energy is re-emitted and an electron not emitted. This gives direct experimental evidence to the "quantized" nature (and thus particle property) of light. Continuing to move forward the theory of the dual-nature of both matter and energy - both exhibit particle and wave properties.

46. b Although I suspect it will not be in the MC of the AP exam, and the formula is on the formula sheet, it might be worth remembering $E = h\nu$. Thus a quick estimation of $(4 \times 10^{10})(6.626 \times 10^{-34})$ would only yield "b"

47. c n is the energy level; L is the orbital type - s, f, d, or p; and m_L is the plane or directionality of such orbitals.

48. c An oxide ion would have two extra electrons than the oxygen atom.

49. d Electron affinity is a measure of the ability of an atom to take on another electron. Adding an electron to phosphorus would disturb the stability of a half full energy level, and the electron would be subjected to extra repulsion because it would be forced to enter an orbital that already had an electron.

50. b Arsenic and selenium have a fourth energy level, and since arsenic is further left with a lower effective nuclear charge, it will be the larger